Regenerative Medicine, Stem Cells, and Low-Level Laser Therapy: Future Directives

Article *in* Photomedicine and laser surgery · November 2012

DOI: 10.1089/pho.2012.9881 · Source: PubMed

1 author:

Heidi Abrahamse
University of Johannesburg

Photomedicine and Laser Surgery
Volume 30, Number 12, 2012

Pp. 681–682
DOI: 10.1089/pho.2012.9881

Guest Editorial

Regenerative Medicine, Stem Cells, and Low-Level Laser Therapy: Future Directives

Heidi Abrahamse, Ph.D.

THE IDEA OF BEING able to replace, restore, or regenerate damaged or diseased tissues and organs in order to establish normal function in the human body has never been so prominent and possible than with the development of the field of regenerative medicine. Using material from the body or activating the body's own repair mechanisms to prepare and grow or heal irreparable tissues or organs is now a real possibility, as demonstrated by research and clinical studies published over the last 10 years. Born from the collaboration of several biomedical disciplines and clinical approaches, regenerative medicine promises the real possibility of not only replacing pharmaceutical solutions to disease but also paves the road to a more autologous and holistic approach in clinical treatment of disease and disease control.[1] Historically, the foundation of regenerative medicine was cemented with the successful transplantation of corneas, soft tissue, and bone in the early twentieth century. The first kidney transplantation in 1954 was followed by pancreas, liver, and heart transplants in the 1960s and success continued in the 1980s with heart–lung and living donor liver and lung transplants. Progressively, an increase in demand for tissues and organs and subsequent decrease in organ availability has left a need for new technology to meet the demand for suitable organs and organ donors as well as leading to an increase in the disgraceful enterprise of black market organs. Currently, tissue-engineered skin used for burn survivors and diabetic ulcers, products derived from tissue engineering to induce bone growth and regeneration, as well as the autologous re-introduction of *ex-vivo* engineered bladder are a reality, once again establishing a firm foothold for the development of further and more advanced applications for regenerative medicine.[2]

The discovery of stem cells by the Russian histologist Alexander Maksimov in 1908, as part of his theory of hematopoiesis followed by Joseph Altman and Gopal Das in the 1960s presenting evidence of constant stem cell activity in the brain and the demonstration of self-renewing cells found in the bone marrow of mice by James E. Till and Ernest A. McCulloch in 1963, established stem cell research and the development of stem cell therapy as a new and very promising and exciting discipline for regenerative medicine. Embryonic and adult stem cells are available from a variety of sources and hold variable differentiation potential, not to mention the myriad potential therapeutic applications, albeit associated with some ethical and political concerns. Mammalian stem cells can be sourced from either the embryo or the adult organism.[3] Embryonic stem cells originate from the inner cell mass of blastocysts, whereas adult stem and progenitor cells can be found in various tissues repairing or replenishing adult tissue. Of specific interest and application in regenerative medicine are autologous adult stem cells accessible from bone marrow, adipose tissue, or blood. Contemporary stem cell therapy includes bone marrow transplants for the treatment of leukemia, whereas extensive current research is undertaken for the implementation of stem cell therapy for the treatment of cancer, spinal cord injuries, and Parkinson's disease, as well as multiple sclerosis and muscle conditions including heart disease. The use of vascular grafts for heart bypass surgery and cardiovascular disease treatment have been researched extensively and are at the pre-clinical trial stage.[4] Advances in therapeutic applications do not come without much debate and controversy surrounding risks associated with it. The risk that transplanted stem cells could form tumors and metastasize uncontrollably is but one of the concerns of stem cell therapy. Inducing forced expression of specific genes in order to derive pluripotent stem cells from non-pluripotent cells generate the so-called induced pluripotent stem cell (iPSC). However, significant risk is associated with reprogramming of adult cells to obtain iPSCs. Potentially, this risk could limit their use in patients. The use of viruses to genomically alter the cells may lead to the expression of cancer-causing oncogenes.[5,6]

Low-level laser therapy (LLLT) has been scientifically proven as a beneficial therapeutic modality for numerous diseases and diseased conditions. Using very specific laser and light-emitting diode irradiation parameters, specific cellular activities can be induced, namely, cellular proliferation and viability while stimulating mitochondrial activity, thereby increasing adenosine triphosphate (ATP) production, synthesis of DNA and RNA, and activating cell-signaling cascades including the production of reactive oxygen species (ROS), nitric oxide (NO) release, activating cytochrome c oxidase, and modifying intracellular organelle membrane activity, calcium flux, and expression of stress proteins.[7–10] The molecular mechanism underlying these cellular activities is less well understood, and several research groups are conducting intensive research studies in an effort to elucidate the relation between these biological

Laser Research Centre, Faculty of Health Sciences, University of Johannesburg, Johannesburg, South Africa.

effects. Far more well established are the clinical effects and benefits that LLLT introduces in the diseased conditions. Reduction of pain, anti-inflammatory effects, wound healing, and significant application of LLLT in the field of dentistry are but a few of the clinical applications. However, it is the cellular effect of increasing proliferation and viability that may significantly contribute to the addition of LLLT to the many biomedical disciplines that further augment the successes of regenerative medicine. Low-intensity laser irradiation has been shown to induce stem cell activity by increasing migration, proliferation, and viability; activating protein expression, and inducing differentiation in progenitor cells.[11,12] With the addition of particular growth factors, stem cells can be differentiated into a particular cell type that could be used in tissue engineering and regenerative therapies, particularly autologous grafting.[13] Ideally, stem cells for potential use in regenerative medicine should meet the following criteria: (1) be found in abundant quantities; (2) be able to be differentiated along multiple lineages in a reproducible manner; (3) be able to be collected and harvested in a minimally invasive procedure; and (4) be able to be effectively and safely transplanted to either an allogenic or autologous host.[14,15]

Regenerative medicine has the potential to provide disease-free, functional tissues and organs, improving the quality of life for patients. By introducing autologous stem cell therapy in combination with regenerative medicine, the spectrum of treatment options will increase, largely resulting in improving the audience of deserving people and, finally, by combining regenerative medicine, stem cell therapy and LLLT, the numbers and patients will increase, the applications will expand, and, therefore, the quality of life of millions of people may be improved. Regenerative medicine has the ability to transform the treatment of human disease by introducing combined, innovative new therapies such as stem cell and LLLT that offer faster, complete recovery and reduce the risks of donor organ transplantation rejection through autologous grafts. seem harder to believe than what it is possible. Organ shortages for transplantation purposes, incompatibility of donor and receiver, and organ transplant rejection may become obsolete in the face of regenerative medicine, autologous stem cell therapy, and low- level laser augmentation therapy. Revitalizing or replacing worn-out or diseased body tissue and organs in a "made to order" fashion may well be orchestrated in the future with the use of regenerative stem cell laser therapy.This is a future directive worthy of intensive research and investment.

References

1. Lin, F., Josephs, S.F., Alexandrescu, D.T., Ramos, F., Bogin, V., Gammill, V., Dasanu, C.A., De Necochea-Campion, R., Patel, A.N., Carrier, E., and Koos, D.R. (2010). Lasers, stem cells, and COPD. J. Transl. Med. 8,16–26.
2. Abrahamse, H. (2009). The use of laser irradiation to stimulate adipose derived stem cell proliferation and differentiation for use in autologous grafts. Proceedings of the 7th International Conference of Laser Applications. Amer. Inst. Phys. 1172, 95–100.
3. Zuk, P.A., Zhu, M., Mizuno, H., Huang, J., Furtell, J.W., Katz, A.J., Benhaim, P., Lorenz, P., and Hedrick, M.H. (2001). Multilineage cells from human adipose tissue: implications for cell-based therapies. Tissue Eng. 7, 211–228.
4. De Villiers, J.A., Houreld, N., and Abrahamse, H. (2009). Adipose derived stem cells and smooth muscle cells: implications for regenerative medicine. Stem Cell Rev. 5, 256–265.
5. Zhao, T., Zhang, Z., Rong, Z. and Xu, Y. (2011) Immunogenicity of induced pluripotent stem cells. Nature 474, 212–215.
6. Teoh, H.K., and Cheong, S.K. (2012) Induced pluripotent stem cells in research and therapy. Malays. J. Pathol. 34,1–13.
7. Gao, X., and Xing, D. (2009) Molecular mechanisms of cell proliferation induced by low power laser irradiation. J. Biomed. Sci. 16, 4–30.
8. Drochioiu, G. (2010) Laser induced ATP formation: mechanism and consequences. Photomed. Laser Surg. 28, 573–574.
9. Houreld, N.N., Sekhejane, P., and Abrahamse, H. (2010) Irradiation at 830nm stimulates nitric oxide production and inhibits pro-inflammatory cytokines in diabetic wounded fibroblast cells. Lasers Surg. Med. 42, 494–502.
10. Houreld, N.N., Masha, R. and Abrahamse, H. (2012). Low-intensity laser irradiation at 660 nm stimulates cytochrome c oxidase in stressed fibroblast cells. Lasers Surg. Med. 44, 429–434.
11. Abrahamse, H., Houreld, N.N., Muller, S., and Ndlovu, L. (2010). Fluence and wavelength of low intensity laser irradiation affect activity and proliferation of human adipose derived stem cells. Medtech SA 24, 8–14.
12. De Villiers, J., Houreld, N.N., and Abrahamse, H. (2011) Influence of low intensity laser irradiation on isolated human adipose derived stem cells over 72 hours and their differentiation potential into smooth muscle cells using retinoic acid. Stem Cell Rev. 7,869–882.
13. Abrahamse, H. (2011). Inducing stem cell differentiation using low intensity laser irradiation. A possible novel therapeutic intervention. Cent. Eur. J. Biol. 6, 695–698.
14. Gimble, J.M., Katz, A.J., and Bunnell, B.A. (2007) Adipose-derived stem cells for regenerative medicine. Circ. Res. 100, 1249–1260.
15. Bunnell, B.A., Flaat, M., Gagliardi, C., Patel, B., and Ripoll, C. (2008) Adipose derived stem cells: Isolation, expansion and differentiation. Methods 45, 115–120.

Address correspondence to:
Heidi Abrahamse
Laser Research Centre
Faculty of Health Sciences
University of Johannesburg
P.O. Box 17011
Doornfontein
Johannesburg, 2028
South Africa

E-mail: habrahamse@uj.ac.za